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ABSTRACT

Based on instructional experiences at Charles County Community College, Maryland, this report examines the pedagogical advantage of teaching atomic absorption (AA) spectroscopy with an AA spectrophotometer that is equipped with a microprocessor and video output mechanism. The report first discusses the growing importance of AA spectroscopy in environmental and technical fields and examines the need to incorporate both theory and hands-on experience in teaching the use of a spectrophotometer. Next, the report considers the usefulness of the Instrumentation Laboratories Model 551 microprocessor-controlled spectrophotometer with video output in training students to set up the instrument: run calibration standards to generate a calibration curve; and calculate a sample measurement. This discussion emphasizes that the immediate feedback provided by the microprocessor spares the student the necessity of performing time-consuming, obfuscating tasks, such as "fiddling with" dials, and allows him/her to concentrate on AA theory. The remainder of the report examines the educational value of a spectrophotometer video output component in: videotaping experiment procedures; videotaping various expository demonstrations; so that students can observe the effects of, for example, aspiration rate or flame stoichiometry; videotaping instrument output related to flameless techniques; and aiding the instructor in preparing materials for students prior to performing an AA experiment. (JP)

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Video Output Atomic Absorption Spectrometer
as an Educational Tool in a
Two-Year Technical Curriculum

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THE USE OF A MICROPROCESSOR-CONTROLLED, VIDEO OUTPUT
ATOMIC ABSORPTION SPECTROMETER AS AN EDUCATIONAL
TOOL IN A TWO-YEAR TECHNICAL CURRICULUM

Analysis for metals by atomic absorption spectroscopy is a technique which is becoming more and more ubiquitous in environmental and technical fields. It is increasingly necessary in technical education to teach students how to use the atomic absorption spectrophotometer (AA). This trend brings to mind several questions about educating and training students in the use of AA. At Charles County Community College, CHE 255, Instrumental Analysis, teaches the basic principles and operation of several instruments, including the AA. The class is usually comprised totally of students in either the Pollution Abatement Technology program which deals with water and wastewater treatment, or Estuarine Resource Technology which deals with natural water body ecology. Both two-year degree programs require the course.

In order to plan a successful program dealing with AA, it is first necessary for educators to pinpoint the specific goals at which they will aim in any course covering AA. It is obvious that the student who is well-prepared for work as an analyst will be versed in AA, and that this training will include some practice in the use of an AA, as well as a basic understanding of the physical and chemical principles behind AA. In an attempt to satisfy these two goals, it is useful to choose an instrument which will afford students the opportunity to gain competence in the use of the AA, as well as one which will satisfactorily show students the theory on which atomic absorption spectroscopy is based. The instrument should afford the student fast and easy access to the skills and principles which are desired for him/her to gain. At Charles County Community College, a microprocessor-controlled, Instrumentation Laboratories (IL) Model 551 AA with a video output is used for training in AA. This instrument has many attributes which suit it well to the purpose of instruction in AA in a two-year technical curriculum.

In order to consider the positive educational aspects of the use of a microprocessor-controlled AA, the procedures involved in student use of the two types of AA must be considered, in order to identify several differences which surface when use is made of this type of instrument.

In the use of both types of AA, there are several steps involved. These include instrument set-up and electrical "zeroing," running of standards for the calibration curve, calibration, and sample measurement. Consideration of each of these steps individually allows for evaluation of each one's efficiency in achieving the goals mentioned above.

The instrumental set-up and electrical zeroing are valuable procedures, both in terms of skills gained and understanding of the principles of operation of the AA. The choice of the proper wavelength is necessary and instructional, but access to the data involves consultation of a table, and flame conditions, bandwidth, and other parameters must also be found in a reference source. Setting zero frequently involves "fiddling" with knobs for some time, especially at a very high gain where the adjustment controls are very sensitive or when the signal is noisy. When a microprocessor with video output is part of the system, the analysis conditions may be permanently stored, allowing immediate recall and display. Microprocessor-controlled AA instruments frequently have one control which will automatically assign an absorbance value (ABS) of zero to a "blank" standard. Both of these features serve to eliminate time spent on the initial set-up of the AA. This time can be spent more profitably in actual operation of the instrument, rather than in time spent doing tedious mechanical tasks.

The procedure of running calibration standards, in order to generate a calibration curve, is central in both attainment of skills and understanding of AA analysis. In any AA analysis done in the future by the student, calibration standards will be run, and the assumption of a smooth, continuous calibration

curve is the basic tenet in the theory of AA. When an AA without a microprocessor is used, absorbance readings must be observed, whether from a digital readout or a dial, and a guess at the average value must be made. This can be very problematic with noisy signals, or at low analyte concentrations. When a microprocessor is used, the instrument can read the ABS at specified time intervals, and display it, along with the current average ABS value, on the ABS readout. When the average value becomes constant, the student may be secure in the belief that the true average has been obtained. The microprocessor option also allows for instantaneous statistical analysis and display of standard deviation and RMS for the average ABS value so obtained. This can give the instrument operator a quantitative indication of the precision of the result.

During the calibration procedure, the microprocessor-controlled AA equipped with a video display can display a table of the calibration curve data entered up to that point with standard concentration and ABS value, or it can exhibit a cartesian coordinate plot of the data entered to that point. This allows the student to actually see the calibration curve constructed and to spot any potentially bad data. Any points that seem to be questionable can then be remeasured and reentered with the new ABS reading. This obviates the need to consider poorly entered or read data as a source of student error.

After all standards have been run, and sufficient data is obtained for construction of a calibration curve, the microprocessor equipped with a video output can calculate the best fit curve to the data in seconds and display the resulting curve. In order to command the execution of this curve calculation and plotting, the student need only press one button. If an inflection point occurs in the curve, the calculation does not proceed and "FLEX CURVE" is displayed on the video screen. If this occurs, the student can again examine the

data used and correct any bad entries, or evaluate the concentration range of the standards. After this, depression of one button then allows immediate calculation and display of the calibration curve generated by the new data.

The use of the microprocessor-controlled AA with video output in routine operation, contrasted with that of a "conventional" AA, shows that it is more efficient at presentation of material which students should retain. The principles of AA and requisite skills for routine use of the instrument are demonstrated in a short time period with a minimal amount of distraction of the students' attention to mechanical manipulations. These mechanical manipulations are simple enough so that if they are required in the future, they will be easily mastered. Omission of these tasks allows the students to more clearly focus attention on the important aspects of AA in the limited time allowed for study.

The sample measurement in a microprocessor-controlled AA is performed after generation of the calibration curve, and the answer is given in concentration units with standard deviation values, if desired. In AA instruments without microprocessors, the sample measurement is usually done before the student plots (or calculates) the "best fit" calibration curve. With the microprocessor's immediate feedback on the calibration curve, the student has the simple and convenient option of remeasurement of some standards in an attempt for more precision. If the student can actually see the calibration curve before the sample measurement, the process becomes more meaningful.

Aside from deleting many obfuscating tasks and focusing the student's attention on the central aspects of AA, the microprocessor-controlled AA equipped with a video screen for output can be modified slightly to become an extremely powerful educational tool by tapping the leads to the screen for videotape recording. This allows a direct recording of exactly what the student will see on the screen in the process of an analysis. Use of the videotape by students

before performance of an AA experiment can be very valuable preparation. An AA without video output can also be used to record experimental procedure, but a camera must be used. This requires additional personnel, along with special lighting and editing, while an instructor can record his own videotape directly from the video output instrument if it is suitably modified.

Aside from a videotape demonstrating routine operation of the AA, other uses of this capability can be made. The video output of the IL 551 AA can be selected as a plot of absorbance vs. time for an arbitrary length of time. By operating in this output mode, aspiration of a standard can be begun in the middle of the specified plot time, and the rapid rise in absorbance viewed. Deuterium background correction is available in the IL 551, and at suitable wavelengths, a plot of absorbance vs. time will display both the total absorbance and background absorbance. Time plots of flames at various fuel/oxidant ratios can show the student the background effects due to very rich or very lean flames. By selecting and videotaping various expository demonstrations, the student can observe directly the effects of conditions like aspiration rate, flame stoichiometry, and others. This is in contrast to the oral or written presentation required without an actual plot of absorbance to witness.

Of special interest in the context of videotaping instrument output are the "flameless" techniques--cold vapor Hg analysis, and furnace methods. Both of these techniques involve discrete evanescent atom populations in the beam of the instrument, and videotape recording of a plot of absorbance vs. time can actually show the effects of various conditions on peak shape and height. For example, in the Hg cold vapor analysis, videotaping allows evaluation of the optimum flow rate for maximum sensitivity as well as display of the effects of slow purging of Hg into the beam. In furnace techniques, students can actually see any "spattering" of drops which may occur from heating at a rate slightly

too high. In use of a furnace, a "bad" temperature program can be recorded on videotape to show exactly what happens when heating is too fast, or drying temperatures too high. In the case of furnace techniques, a simple and convenient method of recording a videotaped demonstration is very useful. Without this ability to directly record videotapes, the long and costly camera recording process must be used, and a plot of the actual absorbance as a function of time is not available without significant instrument modification or additional equipment purchase.

Above and beyond the capabilities of "conventional" AA instruments, a microprocessor-controlled AA with video output can be used as an extremely valuable educational tool. The ability to quickly and conveniently record the output of the instrument on a videotape cassette allows instructors to prepare material for student study before performance of an AA experiment. The video output capability gives students valuable insight into exactly what is occurring in both flame and flameless techniques through display of a plot of absorbance vs. time. These plots can be recorded to show students the variation of background signal intensity with various conditions such as wavelength, flame stoichiometry, etc., or, alternatively, to demonstrate the effect on peak height and/or shape of various experimental conditions. These concepts have been, heretofore, very difficult to demonstrate through the use of a "conventional" atomic absorption spectrophotometer.

The previous discussions show how the inclusion of a microprocessor and video output on an AA forms a valuable educational tool. There are two general ways in which inclusion of a microprocessor in an AA increases the efficiency of learning the theory and operation of the AA. First, the microprocessor eliminates the tedium of educationally inefficient mechanical tasks like knob-fiddling in calibration or standardization. Secondly, the microprocessor serves

as an expository tool, by making the calibration curve easily accessible, and feedback on data immediate, for the student. By watching the construction of the calibration curve, the student gains a better understanding of the theory of AA, and inclusion of the video output facilitates this. Visual presentation of calibration curves is routinely done in teaching of AA, but presentation of these curves on a video screen is even more efficient and meaningful for the student.